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ABSTRACT

Title of Thesis: Association of Optimism with Emotional and Cardiovascular Reactivity in Coronary Patients, and Healthy Controls

Angelique C. DeMoncada, Master of Science, 2007

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Optimism is associated with increased physical and mental health in patients with coronary artery disease (CAD). This study examined whether optimism is associated with emotional and hemodynamic correlates in response to acute mental challenges. Participants included 44 CAD patients with implantable cardioverter defibrillators (age 60.77 $\pm$ 9.9, 4 women), 31 CAD patients (age 61.71 $\pm$ 8.0, 8 women), and 50 controls (age 54.74 $\pm$ 10.9, 22 women). Mental challenge tasks involved anger recall and mental arithmetic with harassment. Systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), and emotional responses were assessed during the rest and challenge tasks. Optimism was assessed with the Life Orientation Test. Results revealed that optimism was related to lower SBP responses to acute challenge in healthy individuals and higher SBP responses in ICD patients. No such relationships were found in CAD patients without ICDs. Emotional reactivity did not mediate the relationship between optimism and hemodynamic reactivity. This study revealed that optimism is associated with reduced emotional and hemodynamic responsiveness among healthy controls whereas patients with coronary disease and arrhythmic vulnerability display increased responsiveness rather than

protective effects of optimism. Therefore optimism interventions may provide little benefit to hemodynamic and emotional responsiveness to everyday challenges in the most diseased group.

Association of Optimism with Emotional and Cardiovascular Reactivity in Coronary Patients, and Healthy Controls

by

Angelique C. DeMoncada

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Introduction

Over the past 15 years, behavioral medicine research has increased emphasis on human strengths and resources(Chang, 2001a). This relatively recent trend adds to the traditional focus on identification and treatment of psychological disorders and adverse health behaviors. The psychological variable of optimism has been associated with positive outcomes in many chronic illnesses (e.g. decreased disease symptomology, decreased recovery time, decreased pain, and increased psychological adjustment and increased quality of life (Scheier & Carver, 1992). Dispositional optimism is defined as a relatively stable, generalized expectation that good outcomes will occur across important life domains(Scheier & Carver, 1985). Dispositional optimism has been associated with indicators of physical and mental health, quality of life, and reduced mortality (Scheier et al., 1999).

A growing number of studies demonstrates that optimism is associated with biological processes (e.g. cardiovascular and immune system parameters) (Scheier et al., 1994a) and psychological factors (e.g. social support and active coping) that play an important role in recovery from coronary bypass graft surgery (Scheier, 1999; Scheier, 1989;Fitzgerald et al., 1993). Furthermore, optimism is associated with lower levels of negative emotions such as anger, anxiety, and depression in both healthy and chronically ill individuals which may additionally contribute to positive health outcomes (Peterson & Seligman, 1984).

Previous research suggests that hemodynamic responsiveness to environmental challenges is a true risk factor for CAD (Krantz et al., 2000;

Krantz & Manuck, 1984). Systolic and diastolic blood pressures in response to acute mental challenges are partially related to the individual's emotional response to that mental challenge (Hull et al., 1988). Although previous research demonstrates that optimism does predict clinical events (e.g. non fatal and fatal myocardial infarctions, and ischema), in patients with cardiovascular disease, relatively little is known regarding cardiovascular disease outcome in healthy individuals (Helgeson, 2003a; Helgeson & Fritz, 1999). It is possible that the level of disease severity influences the mechanisms by which optimism affects health outcomes (Kop, 1999; Rozanski, 1998). Therefore, the present study explores whether level of optimism is associated with cardiovascular reactivity in healthy patients, in patients with CAD, and patients with documented vulnerability for arrhythmias.

Biopsychosocial pathways for health benefits related to optimism are illustrated in the proposed conceptual model displayed in Figure 1. In the following paragraphs, biological (i.e. cardiovascular and immune system reactivity to emotional and mental challenge), health behaviors, and psychological (depression and coping style) pathways will be discussed.

Historical Perspective and Definition of Optimism

Initial writings on optimism began in the 17th century(Domino & Conway, 2001a). Beginning in the 17th century, philosophers debated whether humankind was optimistic or pessimistic in general. The formulation of an "optimistic" philosophical position can be traced to the writings of French philosopher René Descartes (1596-1650; (Domino & Conway, 2001a). In a departure from the 17th century philosophical perspective, Descartes asserted the existence of a moral sense of optimism and pessimism by his conviction that human beings are fully capable of improving the state of the world. However, in the early 18th century Voltaire (1694-1778) refuted the necessity of either an optimistic or pessimistic philosophical outlook because these constructs could be conceived as needless if reason is properly applied and confirmed empirically. David Hume's (1711-1776) position was similar to Voltaire's arguing that applying reason to the cosmos leads to skepticism rather than optimism or pessimism (Domino & Conway, 2001b). Thus, no strong consensus existed for either the optimistic or the pessimistic nature of humankind until the end of the 19th century when optimism and pessimism started to be discussed in terms of a psychological trait.

Scholars in psychology and related disciplines incorporated optimistic or pessimistic views of human nature into their theories. For example, Sigmund Freud (1856-1939) included both optimism and pessimism as concepts in his theory of human nature and development. He asserted that humans have a drive towards pleasure (Eros), and death (Thanatos). The drive towards pleasure and happiness represents the optimistic side of human nature and the drive towards death represents the pessimistic aspect of human nature (Freud, 1964). Psychologist William James (1842-1910), was the first to consider optimism and pessimism as applied to individual traits rather than humankind collectively. James considered the metaphysical debate of optimism and pessimism as inexplicable, and claimed that the disposition between optimism and pessimism lies within the individual. The position that optimism and pessimism are individual personality traits has ultimately lead to empirical study and measurement of optimism as a psychological construct.

Dispostional Optimism

The impact of optimism on health has been systematically explored and supported by a wide range of research, primarily focused on chronic illness. Dispositional optimism is the most widely used and researched conceptualization of optimism (Chang, 2001b). Dispositional optimism is defined as a relatively stable, generalized expectation that good outcomes will occur across important life domains (Scheier & Carver, 1985). This definition implies that people maintain a relatively constant level of optimism over time and across different situations. This approach also allows for temporary variability in optimism levels based on current circumstances. The disposition is nonetheless a general tendency to consistently expect positive outcomes(Scheier & Carver, 1985).

Attributional Style

Another approach defines optimism by an individual's use of attributional styles. Attributional styles refer to characteristic ways in which people routinely explain the events in their lives (Seligman, 1984). Internal attributions refer to the tendency to see causes of events as due to the individual rather than forces beyond the individual's control. Stable attributions refer to the tendency to see causes of events as consistent over time versus temporary. Global attributions refer to the tendency to see causes of events as resulting from factors that affect multiple events and that are not specific to a single event (Seligman, 1984). An individual with an optimistic attributional style would explain the source of negative life events as being a consequence of external, temporary, and specific causes, whereas positive events are attributed to internal, stable, and global causes. The pattern is purportedly reversed in pessimistic individuals such that pessimists tend to attribute negative events to internal, stable, and global causes, and explain positive events as the result of external, temporary, and specific events. One of the consequences of these different attributional styles is related to helplessness, i.e., the feeling that nothing an individual does will influence the outcomes of a particular situation (Seligman, 1984). Consequently, an optimist's explanatory style will reduce the experience of helplessness, whereas a pessimist's explanatory style increases the experience of helplessness (Seligman, 1984).

Unrealistic Optimism

Although dispositional optimism and attributional style are the most commonly used conceptualizations of optimism, an additional important dimension of optimism entails "unrealistic optimism" or "optimistic bias". Weinstein (1980) reports evidence that people believe that negative events are less likely to happen to them than to their peers (Weinstein, 1980). This type of optimism is called unrealistic because, on average, participants rated their own risks as 'below average' therefore unrealistically underestimating actual risks. Unrealistic optimism can be both functional and dysfunctional. Unrealistic optimism may increase self esteem, and coping ability, but alternatively, the illusion of invulnerability may hinder the prevention of negative events (Peeters et al., 1997) and potentially reduce the likelihood of changing adverse health behaviors. Therefore unrealistic optimism is not necessarily expected to improve health outcomes.

<u>Measurement of Optimism</u>

Attributional Style Questionnaire

The Attributional Style Questionnaire (ASQ) has been developed to measure optimistic attributional style (Alloy et al., 1984). The ASQ consists of 6 positive and 6 negative event items. For each event, respondents write down one major cause for why that event occurred, and provide ratings across scales that assess internality, stability, and globality. To improve the reliability of the ASQ scales an Expanded Attributional Style Questionnaire (EASQ) was developed (Peterson & Villanova, 1988) by removing the positive event items and adding 18 negative event items. The level of optimism and pessimism are inferred by the specific pattern of attributions. Attributional measures provide therefore an indirect assessment of optimism and pessimism. This inventory has used extensively and has demonstrated satisfactory reliability (Cronbch's alpha = 0.54 – 0.73); (Alloy et al., 1984).

Life Orientation Test

The Life Orientation Test (LOT; (Scheier & Carver, 1985) is the most commonly used measure of dispositional optimism. The LOT is an 8 item measure (plus 4 filler items) of individual difference in dispositional optimism. Four of the items are phrased positively (e.g. in uncertain times, I usually expect the best) and four negatively (e.g. If something can go wrong for me it will). The LOT also includes four filler items to mask the underlying purpose of the inventory, and control for individual response tendencies (see Appendix A). Respondents indicate the extent to which they agree with each of the items using a five-point Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree). The total score ranges from 0-32 with higher scores indicating higher levels of optimism. The high 4-week, test-retest reliability correlation ($r = .79$) is in support of the assumption that optimism is a relatively stable trait over time.

The LOT demonstrated convergent validity with psychological traits assumed to be similar. Specifically, optimistic individuals score higher on measures of self esteem ($r=.48$, $p<.01$), and internal locus of control ($r = .34$, $p<.01$). Although, these correlations are of moderate magnitude, they are not so strong as to negate the independence of optimism as a distinct construct. Similarly, evaluations of divergent validity have yielded results in the expected direction. Optimistic individuals score lower on measures of perceived stress, ($r = -.55$, $p<.01$), depression ($r = -.49$, $p<.01$), hopelessness ($r = -.47$, $p<.01$), and powerlessness ($r = -.40$, $p<.01$; (Scheier & Carver, 1985).

The LOT was revised in 1994 to minimize overlap of item content with other constructs, specifically coping style (Scheier et al., 1994b). The LOT-R contains 6 items (plus 4 filler items). Two items were eliminated because they appeared to evaluate coping style, a hypothesized mediator of optimism, and because of the use of metaphors, which may be culturally specific (i.e., "I'm a believer that every cloud has a silver lining" and "I always look on the bright side of life"). One negatively worded item ("Things never work out the way I want them to") was changed to a positively worded item positive item ("Overall, I expect good things to happen to me") to ensure the same number of positive and negative items. These changes resulted in three positively worded, three negatively worded items and four filler items. The test-retest reliability of the LOT-R is satisfactory (r = .68 at four months, r = .60 at 12 months, r = .56 at 24 months, and r = .79 at 28 months). Analyses of convergent and divergent validity of the LOT-R reveal that optimism and related traits are significantly related to lower depression levels. Factor analysis has also shown that optimism can be considered as a separate construct from self-mastery, self-esteem, or neuroticism (Scheier et al., 1994a). In this thesis, optimism will be defined as a dispositional trait, consistent with the aforementioned definition formulated by Scheier & Carver (1985) and measured with the original LOT.

Few studies have assessed optimism using both the LOT and ASQ. Chang (2001), reports that the magnitude of overlap between the two measures has been inconsistent, with correlations ranging from .20 to .77. Although both the LOT and ASQ are associated with many of the same outcomes (i.e. decreased depression and health benefits), these findings may reflect the differences in the theoretical models underlying each measure. The LOT measures expectancy of both positive and negative events and is future oriented, whereas the ASQ measures causal attributions of past events. The current study focuses on predicting emotional and cardiovascular responses to current stressors, and therefore the LOT conceptualization is more relevant than the ASQ when assessing biobehavioral correlates of optimism.

There has been debate over whether optimism versus pessimism are two extremes of the same psychological dimension, or whether these constructs are inversely related but not necessarily opposites. Hummer, Dember, Melton and Schefft (1992) argue that optimism and pessimism may not be extensions of the same trait but rather are separate, albeit related, constructs. The authors developed a 56 item Optimism/Pessimism Scale which assesses level of optimism and level of pessimism. Scores on this scale suggest individuals can be classified into one of four possible categories: (1) optimists - high optimism/low pessimism; (2) defensive pessimists - high optimism/high pessimism; (3) genuine pessimists - low optimism/ high pessimism; and (4) undifferentiated - low optimism/low pessimism. The authors reported a subset of individuals who score both high on optimism and high on pessimism (category 2, defensive pessimists), indicating that optimism and pessimism are not necessarily polar opposites. However, tests conducted to determine the extent by which the defensive pessimist group differed from the optimist and genuine pessimist groups on other measures such as the Beck Depression Inventory, indicated that individuals in the defensive pessimism category scored between the optimists and genuine pessimists (Hummer et al., 1992). These findings suggest that the optimism-pessimism polarity probably reflects a uni-dimensional construct, which is consistent with the conceptualization by Scheier and Carver

(1985). The present study will examine the total LOT score as well as separate exploratory analyses for positive (optimism) and negative (pessimism) items.

Health Consequences of Optimism

A relatively large literature indicates that optimism contributes to health outcomes in a number of chronic illnesses. Positive health outcomes (e.g. decreased disease symptomology, faster recovery times) have been demonstrated in patients with early stage breast cancer (Carver et al., 1993), multiple sclerosis (Barnwell & Kavanagh, 1997), diabetes mellitus (Kavanagh et al., 1993), rheumatoid arthritis (Brenner et al., 1994), and in women 65 years of age and older (Boland & Cappeliez, 1997). Additionally, Schultz and colleagues (1996) have reported that the presence of pessimism is a strong predictor of mortality in cancer patients (Schulz et al., 1996a).

Several studies have examined whether optimism is a protective factor in coronary artery disease (CAD) progression. In two studies Scheier and colleagues (1989, 1999) investigated the effects of optimism on recovery from coronary artery bypass graft (CABG) surgery. After controlling for extensiveness of patients' surgery, severity of underlying CAD, and major CAD risk factors, optimism predicted improved recovery in both studies. Scheier et al. (1989, 1999) also found that optimistic individuals had fewer perioperative myocardial infarctions (MI; $F(1, 46) = 7.82$, $p<.01$), demonstrated more rapid recovery during hospitalization ($F(1, 44) = 6.67$, $p<.02$), had a faster return to normal daily routine ($F(1,42) = 6.92$, $p<.02$), took a more active role in the recovery process ($F(1,45) = 10.18$, $p<.005$), and reported greater life satisfaction 6 months following surgery ($F(1,43) = 34.16$, $p<.0001$; Scheier et al., 1999). Results further revealed that all-cause rehospitalization was lower among optimistic than pessimistic individuals, including post surgical sternal wound infection, angina, MI, need for angioplasty, and need for another bypass surgery ($N=247$, $b=-.09 \pm .04$, $p<.05$; odds ratio = .77, 95% confidence interval = 0.57 – 1.05). These effects were independent of self-esteem, depression, and socioeconomic status (Scheier et al., 1999).

In a study investigating long-term disease progression and psychological adjustment among angioplasty patients optimism, again, contributed to positive health outcomes (Helgeson & Fritz, 1999). Optimism, combined with self-esteem, and locus of control were assessed and calculated into a Cognitive Adaptation Theory Index (CATI). Higher CATI scores predicted fewer cardiac events, better mental health, higher levels of vitality, more positive health perceptions, and higher quality of life. These results were observed at both the 6-month and 4-year follow up (Helgeson, 2003b; Helgeson & Fritz, 1999). Additional studies have further demonstrated positive effects of an individual's explanatory style (referred to as optimism) in CAD patients. Kubzansky and colleagues (2001) assessed optimistic explanatory style using the Optimism-Pessimism Scale in the Normative Aging Study, and found a protective dose-response relationship between higher levels of optimism and reduced occurrence of nonfatal MI, angina pectoris (relative risk 0.45, 95% confidence interval = 0.29 - 0.68), and fatal cardiac events (relative risk of 0.44, 95% confidence interval = 0.26 - 0.74) during 10 year follow-up (Kubzansky et al., 2001; Malinchoc et al., 1995). Shnek and colleagues (2001) established that optimism levels predicted depression in hospitalized patients with ischemic heart disease at 1 month and 1 year post discharge, whereas self efficacy measures did not. Finally, Mahler and Kulik (2000) have confirmed that high optimism is associated with less pain early during recovery from coronary bypass surgery. Although all but the most pessimistic patients reached similarly low levels of pain by the 12 month follow up (Mahler & Kulik, 2000).

Giltay and colleagues (2004) examined the relationship between optimism and all-cause and cardiovascular mortality in the prospective cohort of elderly Dutch men and women in the Netherlands over 9.1 years. Adjusting for age, sex, chronic disease, education level, smoking, history of cardiovascular disease and hypertension, body mass index, total cholesterol level, and alcohol consumption, individuals with high optimism (upper vesus lower quartile) had a hazard ratio of.23 (95% confidence interval, 0.10 - 0.55; p,0.001; (Giltay et al., 2004; Giltay et al., 2006). These studies demonstrate that optimism positively affects health outcomes in a variety of medical disorders, including coronary artery disease.

Biopsychosocial Pathways for Cardiovascular Benefits of Optimism

There are a number of possible pathways by which optimism may provide cardiovascular benefit. Optimism may influence pathogenesis of cardiovascular disease and subsequent cardiac events biologically by decreasing cardiovascular reactivity to mental stress, or increasing the responsiveness of the immune system. Further, optimistic individuals may be more inclined to engage in health behaviors than pessimistic individuals, thereby increasing cardiovascular health. Psychological factors associated with optimism such as decreased depression, increased social support, and coping style may also be responsible for cardiovascular outcomes. The following sections explore biobehavioral correlates and potential cardiovascular benefits of optimism.

1. Pathogenesis of Coronary Artery Disease and Cardiac Arrhythmias

Because little is known about how the level of disease severity or nature of disease may impact the pathways by which optimism affects health outcome, the present investigation will examine the associations of optimism with emotional and cardiovascular reactivity in ICD patients with CAD, CAD patients without ICD, and healthy controls. Coronary artery disease is the leading cause of death in the United States (American Heart Association, 2006). CAD involves coronary atherosclerosis which can lead to myocardial ischemia and myocardial infarction (MI). Atherosclerosis results when fatty deposits or plaques narrow the coronary arteries, which deliver blood to the heart. Myocardial ischemia occurs when the narrowed coronary arteries cause inadequate blood flow to the cardiac tissue. Ischemia can be induced by an increase in cardiac demand or a decrease in supply of oxygenated blood to the heart. When myocardial ischemia is prolonged or severe, cardiac tissue dies causing myocardial infarction (MI). MI and severe myocardial ischemia are known triggers of life threatening cardiac arrhythmias and may lead to sudden cardiac death (Muller and Verrier, 1996; Krantz and Lundgren, 2002).

Several psychosocial risk factors for CAD have also been identified in addition to the traditional cardiovascular risk factors such as hypertension, smoking, and hyperlipidemia. These include low socioeconomic status, low social support, the hostility component of Type A behavior, and depression (Gatchel et al., 1982). Psychological risk factors can be categorized as, chronic (e.g., hostility), episodic (e.g., depression), or acute (e.g. anger; Kop, 1999). Chronic psychological distress has been shown to affect an individual's risk of developing CAD (Kaplan & Bush, 1982). Acute mental stress and anger have been shown to induce myocardial ischemia and myocardial infarction in patients with CAD (Blumenthal et al., 2002; Ironson, 1992; Rozanski et al., 1994). Physiologic indicators of increased cardiac demand (elevated heart rate) and decreased cardiac supply (vasoconstriction of arteries) can occur in response to acute mental challenges (Kop, 1999). Myocardial Infarction and prolonged CAD may lead to left ventricular dysfunction and vulnerability to arrhythmias (Carels, 2003). Further, research demonstrates that mental stress induced myocardial ischemia and exaggerated hemodynamic responses to mental stressors predict subsequent clinical cardiac events in patients with CAD (Krantz & McCeney, 2002). Therefore the present investigation examined the association between optimism and cardiovascular reactivity. Implantable cardioverter-defibrillators (ICDs) have been used to interfere with life-threatening ventricular arrhythmias since 1980 (Mirowski, 1980). The purpose of an ICD is to monitor heart rhythm and treat detected abnormal heart rhythms by providing pacing, synchronized cardioversion, or defibrillatory shocks. ICDs are used in patients at risk for recurrent, sustained ventricular tachycardia or fibrillation. The device is connected to leads positioned inside the heart or on its surface. These leads are used to deliver electrical shocks, sense the cardiac rhythm and sometimes pace the heart, as needed. The various leads are tunnelled to a pulse generator, which is implanted in a pouch beneath the skin of the chest or abdomen. These generators automatically monitor and treat heart rhythms recognized as abnormal. When an implantable cardioverter defibrillator detects ventricular tachycardia or fibrillation, it shocks the heart to restore the normal rhythm.

The inclusion of ICD patients in this study will allow for an examination of potential relationships between optimism and individuals vulnerable to arrhythmias. Optimism is hypothesized to be related to biological processes relevant to CAD and arrhythmias such as cardiovascular reactivity to mental stress and immunological responsiveness.

2. Biological Factors Related to Optimism

(a) Cardiovascular reactivity to mental stress

Mental stress reactivity can be defined as the change of hemodynamic and emotional responses from baseline levels to acute (mental) challenge tasks (Krantz & Manuck, 1984; Krantz & McCeney, 2002). Hemodynamic and emotional reactivity to a mental stress has been shown to predict subsequent BP levels and development of hypertension (Ketterer et al., 2000). Exaggerated cardiovascular reactivity appears to be an independent risk factor for the development of cardiovascular disease (Helmers & Krantz, 1996; Jiang et al., 1996; Kaplan, 2003; Krantz & Manuck, 1984). Several studies have linked activation of sympathetic nervous system with progression of atherosclerosis (Kaplan, 2003). Evidence further suggests that stress-related sympathetic activation may potentiate endothelial injury, precipitating the development of cardiovascular disease (Kaplan, 2003).

Few studies have examined the possible protective factors such as optimism involved in the converse reaction to mental challenge. It is useful to examine pathways that may dampen hemodynamic and emotional responses to stress to determine possible protective effects on cardiovascular health. A study conducted by Raikkonen and colleagues (1999) equipped healthy participants with an ambulatory blood pressure monitor for three days combined with a mood diary. Analysis of the data revealed that pessimists had significantly higher average SBP and DBP than optimists. The authors conducted further analyses to determine the effects of mood on ambulatory blood pressure and found that pessimistic individuals had higher SBP and DBP than optimistic individuals throughout the 3 days regardless of positive or negative mood. Pessimists did experience more negative mood than optimists, however, when the optimists did experience negative mood, they exhibited BP levels as high as those observed in the pessimists (Raikkonen et al., 1999). Van Treuren & Hull (1986) conducted a study measuring systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) responses during a computer-presented logic task.

Participants were given either success or failure feedback during the task and measurements of SBP, DBP, and HR were recorded before, during, and immediately after the task, as well as after a three minute recovery period. Optimists exhibited a decrease in SBP over time, whereas pessimists exhibited increases from pretask to posttask measurement, and then decreased from posttask to recovery. An interaction of optimism, time and condition was observed for measures of DBP and HR. DBP and HR levels of participants high on LOT-assessed optimism decreased from pretask to posttask, but only in the success-feedback condition. For the other groups DBP and HR rose from pretask to posttask and then declined from posttask to recovery. These studies suggest that increased negative mood during mental challenge may influence the cardiovascular reactivity displayed by optimists and pessimists (Raikkonen et al., 1999). However, both of these studies were conducted using healthy individuals and additional research is needed to determine whether these relationships are sustained in cardiovascular patients.

(b) Immune System Responsiveness

Immunological pathways have been hypothesized to partially account for the relationship between optimism and positive health outcomes. Inflammatory processes are known to contribute to the progression of coronary atherosclerosis and CAD (Schwartz, 2003). Although no studies have been conducted on cardiac patients, there is evidence supporting the possibility that optimism may affect immune system function in other chronically ill populations. Optimism has been associated with higher numbers of T-helper cells and higher natural killer cell cytotoxicity (NKCC) in first semester law students (Segerstrom et al., 1998) , extent of immune response to antigen challenge in older adults (Kamen-Siegel et al., 1991), slower immune decline in HIV positive individuals (Aspinwall et al., 1991), longer survival time in AIDS patients (Reed et al., 1999), and increased T lymphocyte immune cells in response to stressors lasting less that 1 week in healthy women (Cohen et al., 1999). In opposition to these findings, optimists also display *decreased* T lymphocyte immune cells in response to stressors lasting longer than 1 week (Cohen et al., 1999), and a larger decrement in NKCC when exposed to uncontrollable noise (Sieber et al., 1999). Kiecolt-Glaser and colleagues (1984) demonstrated that non-depressed individuals display stronger immune system parameter responses to pathogens than depressed individuals (Kiecolt-Glaser, 1984). As discussed below, optimism may therefore affect immune functioning by reducing vulnerability for developing depression (Scheier & Carver, 1987). Thus, it is unclear to what extent optimism directly affects immune system function in the setting of either acute or chronic stress**.** The effects of optimism on immune system function will not be addressed further in this thesis.

3. Health Behaviors and Optimism

It is well known that negative health behaviors (e.g. diet, exercise etc.) increase risk and are related to cardiovascular disease progression (Krantz & McCeney, 2002). As shown in the conceptual model (Figure 1), optimistic individuals are expected to engage in more health behaviors than pessimists because optimists attend to risk behavior information, particularly when it pertains to them personally(Abele & Petzold, 1996; Aspinwall & Brunhart, 1996), and because optimists are more likely to expect positive outcomes when engaging in health behaviors.

Consistent with this theory, research has demonstrated that optimism predicts engagement in health behaviors in a number of chronically ill populations (Robbins et al., 1991). Taylor and colleagues (2000) found that optimistic HIV-positive men made greater efforts to maintain health through diet and exercise (Taylor et al., 2000). Strack and colleagues (1987) reported that optimism predicted successful completion of a 90-day aftercare program following treatment for alcoholism (Strack et al., 1987). Optimistic people were more likely than pessimistic people to make the concrete and overt behavioral changes necessary to succeed during the transition program.

Little research has been conducted on the relationship between optimism and health behaviors in CAD patients. Two studies demonstrate more engagement in healthy behaviors among optimistic cardiac patients. In a 18-week cardiac rehabilitation program, optimism predicted success in making health changes associated with cardiovascular disease, including increasing aerobic activity, decreasing weight, as well as portion of saturated fat in diet, and blood cholesterol levels (Shepperd et al., 1996). Interestingly, Mumby and colleagues (1995) have shown that although optimistic individuals tended to underestimate their susceptibility to hypertension, engagement in health behaviors was higher, and stress and physical symptoms were reduced. These findings add to the evidence that optimistic individuals take a more active role in treatment and recovery by engaging in health behaviors. Health behaviors will be addressed as potential covariates in this thesis.

4. Psychological Factors

Optimism affects several psychological factors that are known to influence health outcomes. Patients with optimistic outcome expectancies display decreased depressive symptoms, increased social support, and increased engagement in dealing with health-related issues, even when confronted with uncontrollable or unattainable aspects of health in a variety of chronic diseases (Fournier et al., 2002).

(a) Depression

Optimism may indirectly improve health outcomes by reducing the incidence of depression in chronically ill individuals. Depression occurs in the context of physical illness more frequently than in the healthy population and is associated with poorer health outcomes including increased mortality in chronically ill patients (McDaniel et al., 1995). There is an extensive literature demonstrating that optimism correlates negatively with depressive symptoms and distress (Carver & Gaines, 1987; Hummer et al., 1992). Shnek and colleagues (2001) have documented that optimism was the only significant predictor of decreased depression among ischemic CAD patients one year following hospital discharge, whereas measures of cognitive distortions, self esteem, and helplessness were not predictive of depression. Penedo and colleagues (2003) studied men who had recently undergone a radical prostatectomy, and report that optimism predicted perceived stress management skills which in turn predicted positive mood (Penedo et al., 2003). Thus, evidence suggests that optimism is associated with reduced concurrent and future depression.

(b) Social Support

Social support may be another mediator accounting for the relationship between optimism and improved physical health. The amount of social support has been shown to improve health outcomes (Berkman & Syme, 1994; Cobb, 1976). Many studies have shown that social isolation is a consistent predictor of poorer health outcomes (Berkman & Syme, 1994; Cobb, 1976; Kaplan & Bush, 1982; Uchino et al., 1996). Evidence suggests that optimists tend to seek out both instrumental and emotional social support, whereas pessimists often have less social support (Anderson & Arnoult, 1985; Scheier et al., 1999). Recently, Shen and colleagues (2004) reported that optimistic cardiac patients reported greater levels of social support and that the increased social support was related to improved physical functioning following 6 weeks of treatment.

(c) Coping Style

Substantial differences exist in how optimistic and pessimistic individuals cope with critical life situations. Optimistic individuals tend to use more active coping strategies and exert more effort towards goal attainment (Scheier et al., 1999). Even when confronted with serious adversity, optimistic individuals are more likely to exert continuing active coping efforts rather than using avoidant coping styles such as denial or wishful thinking.

One study suggests that optimistic cardiac patients more frequently use problem-focused coping strategies when situations are viewed as controllable, and use more positive reframing when situations are deemed uncontrollable than pessimistic individuals (Scheier, Carver, and Bridges, 1994). Carver and colleagues (1993) found that optimism was associated with a pattern of active coping strategies, and that optimistic and pessimistic patients' coping tactics strongly related to the self-reported distress (Carver et al., 1993). Consistent with the aforementioned observations in CAD, the coping differences mediated the relationship of optimism and decreased depression and distress.

In Scheier and colleagues' (1989 and 1999) studies on coronary artery bypass surgery patients, optimism was associated with active coping styles, information seeking, goal setting for recovery, and reframing adverse situations. Pessimistic patients tended to use fatalism, self blame, focus more on the negative aspects of the situation, and use escapism. Positive health effects of optimism of post CABG surgery recovery were mediated by the effect of coping differences (Wrosch & Scheier, 2003). Coping style will not be directly addressed in this thesis, but the effects of emotional responsiveness on the relationship between optimsism and vardiovascular reactivity will be examined in detail.

<u>Summary and Hypotheses</u>

Dispositional optimism is related to a variety of health outcomes including reduced recurrent fatal and non-fatal events in individuals with CAD (Giltay et al., 2004; Giltay et al., 2006; Helgeson, 2003a; Helgeson & Fritz, 1999; Scheier et al., 1999; Scheier et al., 1989). Substantial progress has been made in delineating pathways accounting for the association between optimism and reduced adverse health outcomes. Support exists for biological mechanisms such as decreased cardiovascular and immune system reactivity, psychological mechanisms including decreased depressive symptoms, increased social support, and increased use of effective coping strategies, and increased health behaviors (see Figure 1).

Elevated hemodynamic reactivity to stress is associated with myocardial ischemia, and recurrent non-fatal, and fatal myocardial infarction. The magnitude of emotional response to acute mental challenge is related to hemodynamic reactivity (Shnek et al., 2001). The reviewed evidence suggests that optimism levels are associated with reduced occurrence of primary and secondary cardiac events (Helgeson, 1999, 2003). Therefore the pathophysiologic mechanism explaining the association between optimism, and adverse cardiovascular health outcome may be related to attenuated hemodynamic reactivity to acute mental stressors. One study of healthy participants suggests that the relationship of optimism and hemodynamic reactivity to acute mental stressors may in part be mediated via emotional reactivity (Raikkonen et al., 1999). This relationship has been largely unexplored in cardiac patients.

As shown in Figure 2, the purpose of this study is to investigate whether dispositional optimism is associated with decreased emotional and cardiovascular reactivity to mental challenges in cardiac patients and healthy individuals. The specific hypotheses for the current study are:

Hypothesis 1 (H1): Optimism will be associated with lower negative emotional responses during mental challenge tasks.

Hypothesis 2 (H2): Optimism will be associated with lower cardiovascular responses (SBP, DBP, and HR) during mental challenge tasks (defined as difference between peak and baseline levels).

Hypothesis 3 (H3): The reduced cardiovascular responsiveness among optimistic individuals (H2) is mediated by the attenuated emotional response to mental challenge (H1).

To determine whether disease severity influences the optimism-reactivity relationships, these hypotheses will be examined in three groups: healthy controls, CAD patients, and CAD patients with an ICD. Although research has established patients with cardiovascular disease tend to have higher hemodynamic reactivity, no a priori differences across the groups are anticipated in the optimism-reactivity associations. Hemodynamic responses will also be assessed during an exercise task to control for differences in cardiovascular reactivity independent of mental challenge.

RESEARCH DESIGN AND METHODS

General Overview

Data were obtained from two studies previously conducted at the Uniformed Services University, "Biobehavioral triggers of ventricular arrhythmias" (1RO1HL0473370; primary investigator D. Krantz, Ph.D.) in the following referred to as Triggers of Arrhythmias in Defibrillator Patients (TRIAD) and "Behavioral and immunological factors in coronary disease" (5R01HL06614905; primary investigator, W. Kop, Ph.D.) in the following referred to as Coronary Angioplasty Recurrent Events Study (CARES). Patient testing and data collection were conducted at the Washington Veterans Administration Medical Center, Washington DC; INOVA Fairfax Hospital, Fairfax, VA; St Francis Hospital, Roslyn, NY; and the Washington Hospital Center, Washington DC.

<u>Participants</u>

<u>ICD patients (N = 44)</u>

Inclusion criteria: (1) documented CAD based on prior diagnostic angiography or history of MI, and (2) ICD.

Exclusion criteria: (1) primary diagnosis of cardiomyopathy, (2) acute or recent (< 1 month) myocardial infarction; (3) severe congestive heart failure; (4) significant neurological or psychiatric disability (5) unstable angina, (6) critical valvular pathology, and (7) refusal of informed consent.

<u>CAD patients (N = 31)</u>

Inclusion criteria: (1) documented CAD based on prior diagnostic angiography or history of MI.

Exclusion criteria: (1) acute or recent (< 1 month) myocardial infarction; (2) severe congestive heart failure; (3) severe valvular pathology; (4) use of immunomodulatory or anti-inflammatory medication other than aspirin; (5) failed revascularization (i.e. residual stenosis > 50%

or < 20% luminal gain); (6) Recent (< six months) revascularization and (7) refusal of informed consent.

Healthy controls (N = 50): age matched normal volunteers with < 5% likelihood of CAD were recruited via advertisements in local newspapers and tested as controls.

The sample consisted of 50 healthy controls, 31 CAD patients, and 44 CAD patients with ICDs (see Table 1).

Procedures

The current study examined a subset of the measures of the TRIAD and CARES protocols. CARES participants (N = 39) participated in (1) cardiovascular revascularization, blood draw, and questionnaires, (2) laboratory phase with mental stress and exercise tasks 2 – 4 weeks following revascularization, and (3) follow-up at 8 months phase with questionnaires. The current study integrated the second and third components including questionnaires relevant to the assessment of optimism and emotional and hemodynamic reactivity. TRIAD participants (N = 86) completed the LOT during the first day of testing, whereas the CARES participants completed the LOT during the 8-month follow-up phase of the study.

Laboratory Protocol

The laboratory protocol involved a 20 minute rest during which the participants' physiological baseline levels were obtained after which the mental challenge tasks were performed. Concurrent with rest periods and mental stress tasks, measures of cardiovascular (SBP, DBP, HR), and emotional reactivity were obtained (see Figure 3).

Mental Stress Testing

The protocol for mental stress testing was the same for TRIAD and CARES patients. Following the 20 minute rest period individuals were asked to complete 2 mental stress tasks with no rest period between tasks. <u>Anger Recall Task</u>: Participants were asked to recall a recent incident that was extremely irritating or upsetting. The participant was asked to mentally relive the situation, and asked to make a four minute speech about the incident, to recreate the situation, talking about the events especially regarding the participant's thoughts and feelings during the event (Ironson, 1992).

<u>Mental Arithmetic Task</u>: A standardized audiotape was used and participants were asked to verbally subtract serial 7's from a 4 digit number for a period of 5 minutes. Participants were instructed that their performance would be rated for speed and accuracy, and to try as hard as they could. As the participant performed the task, the experimenter interrupted and harassed the individual with prompts such as 'Try as hard as you can' and 'Go quickly.'

Exercise Task

TRIAD participants were asked to complete a bicycle tolerance test. The bicycle test was performed with workload increasing in 3-minute stages and hemodynamic measurements were taken during the last minute of each stage. The exercise protocol administered in the TRIAD study was conducted on a different day than mental stress testing and differed from the exercise protocol used in the CARES study. CARES participants performed a standard exercise treadmill test using the Bruce protocol, with hemodynamic measurements taken during the last minute of each 3-minute stage. Exercise tests were discontinued when participants reached 80% of predicted heart rate or if cardiac arrhythmias occurred. To ensure that differences in the exercise protocols of CARES and TRIAD do not differentially impact the results, data analysis will only be conducted on the TRIAD exercise data (n=86). Participants hemodynamic reactivity to exercise will be used to demonstrate that optimism is associated with reactivity to mental challenge but not physical challenge.

Measures Obtained During the Study

Assessment of Optimism

Dispositional optimism was assessed using the Life Orientation Test (LOT; Scheier and Carver, 1985). The LOT is a 12 item measure that includes eight items assessing optimism (e.g. "In uncertain times, I usually expect the best") plus four filler items designed to mask the underlying purpose of the inventory, and control for individual response tendencies (e.g. "It's easy for me to relax"; see Appendix A). Respondents indicate the extent to which they agree with each of the items using a five-point Likert scale ranging from (0 to 4; total scale range 0-32) higher scores indicate higher levels of optimism (Scheier et al., 1994a).

Norms for the LOT have been computed for a sample of college students (357 men and 267 women). The means and standard deviations for men and women are 21.03 $\pm$ 4.56 and 21.41 $\pm$ 5.22 respectively. The high 4-week, test-retest reliability correlation (r = .79) is in support of the assumption that optimism is a relatively stable trait over time. In a study assessing optimism levels among stroke patients and their primary support providers, stable optimism scores have also been observed over a 6-month interval (Schulz et al., 1996b). The mean LOT score for the stroke patients decreased from 22.2 $\pm$ 5.86 to 21.4 $\pm$ 5.54 (not statistically significant); and scores for the support persons dropped from 21.95 $\pm$ 5.13 to 21.10 $\pm$ 5.33, which was statistically significant although the effect size was quite small. The statistically significant decreases in optimism scores (among providers) may partially reflect the high correlation between baseline and follow-up assessments resulting in small variances of the difference scores (Schulz et al., 2000). These findings therefore indicate that the LOT scores are robust in the face of major health problems and challenges of daily life.

Norms for the LOT-R (3 positive, 3 negative, and 4 filler items) have been computed on a sample of college students and a sample of patients awaiting coronary artery bypass surgery. The means and standard deviations for college students (1,394 men, 622 women) and bypass patients (122 men, 37 women) are: 14.28 $\pm$ 4.33, 14.42 $\pm$ 4.12, 15.24 $\pm$ 4.09, and 14.92 $\pm$ 3.97 respectively. Additional data have been collected to compare optimism as measured by the LOT-R to other personality traits with regard to its ability to predict physical symptoms, coping, and depression (Scheier, Carver, and Bridges, 1994). Moderate correlations were found between optimism and self-mastery ($r = .48$, $p<.001$), trait anxiety ($r = -.53$, $p<.001$), neuroticism ($r = -.43$, $p<.001$), and self esteem ($r = .50$, $p<.001$), suggesting both convergent and divergent validity of the optimism construct. The present study will primarily examine the original

LOT (8 items). We will also present negative and positive component scores (4 items each).

Emotional Reactivity to Mental Challenge

At completion of the baseline resting period participants were asked to rate how they were feeling on a Likert scale of 1 (not at all) to 7 (very much). The items included: interested, anxious, frustrated, irritated, angry, challenged, tired, and depressed. Participants were trained on the Likert scale prior to the first rest period. Ratings were obtained following the baseline, and at the completion of both mental challenge tasks. Participants' ratings for each task will be used to determine emotional reactivity to the mental challenge task without correcting for baseline levels of the Likert scales (Scheier, Carver, and Bridges, 1994). Baseline ratings will be used to determine whether there are initial differences between the study groups and whether optimsm is related to a positive response set during resting conditions (i.e., in the absence of mental stress). Anger ratings were also taken following the anger recall task to determine the effectiveness of the anger recall task.

Hemodynamic Measures

During rest and challenge tasks, blood pressure and heart rate were obtained at 2-minute intervals using a Critikon Ditimap automated cuff placed on the non-dominant arm. Participants were asked to refrain from moving their arm while the cuff was inflated. SBP, DBP, and HR were obtained every two minutes throughout the protocol. Resting blood pressure and heart rate levels were determined by averaging the last three resting measures during the rest period. During mental challenge tasks, hemodynamics were assessed every 90 seconds (the peak of these measurements was recorded). Arithmetic change scores were calculated by subtracting the peak task measures from the preceding baseline measures (Krantz et al., 1999). This procedure allowed determination of increases in hemodynamic measures while adjusting for baseline levels.

Methods of Calculating Reactivity

Three strategies for calculating reactivity scores have previously been described: (1) the aggregated baseline change scores strategy where the entire combined baseline measures prior to a series of tasks are averaged to compute an overall baseline to subtract from individual task level; (2) the residual change score method, where a regression line is calculated for the relationship between baseline and task measures and then the residual values from the regression line are used as the reactivity measures; and (3) arithmetic change scores calculated by subtracting the peak task measures from the preceding baseline measures (Kop et al., 2000).

Kamarck et al. (1992) support an aggregated baseline across tasks as the proper manner in which to perform a baseline cardiovascular evaluation because the “baseline” cardiovascular measures tend to drift upwards across repeated challenge tasks (Kamarck et al., 1992). However, in the paradigm employed by Kamarck et al. (1992), each task lasted approximately 6-10 minutes with a minimal rest period (< 5 min) between each task (Kamarck et al., 1992). Therefore, the challenge period was quite long and the recovery time was short. In the present study, a longer recovery period of 10 minutes was used between mental challenges and exercise. Because the recovery periods in the present study are longer than in the Kamarck et al. (1992) protocol, baseline drift was not expected to be a problem in the present investigation.

Manuck et al. (1989) provide evidence in support of a residual change score approach. The residualized change score provides a means of quantifying the physiologic responses to challenge tasks, while separating the influence of baseline levels from these responses. Although, there are occasions in which the residualized change score differs from the arithmic change score, these occasions are rare (Manuck, 1989). Also, the reliability of both residualized change scores and basic arithmetic change scores are comparable (Kamarck et al., 1992). Furthermore, the residual change score approach postulates a linear relationship between baseline and task levels, which is not necessarily a valid assumption.

Therefore, arithmetic change scores from baseline to peak levels during the anger recall and the math tasks were used in this study because this method is directly based on the raw data and it is comparable in reliability and outcome to the other two methods (Kamarck et al., 1992; Manuck et al., 1989).

Statistical Analyses

The study hypotheses were tested using multivariate regression analyses. Bivariate correlation analyses were first conducted to examine the associations among the study variables. The study variables were then entered in a hierarchical linear regression model after controlling for gender, age, cardiovascular disease risk factors (i.e. hypertension, insulin dependent diabetes mellitus, smoking, and body mass index; BMI) and severity of CVD (i.e.

measures of ejection fraction, angina, and dyspenea), and hemodynamic factor (i.e. SPB, DBP, and HR) baseline levels. For all the analyses, a two-tailed significance level was set at .05. Data were analyzed using SPSS for Windows Version 12 (SPSS Inc; Chicago, Illinois). Data analyses for each of the hypotheses were as follows:

Hypothesis 1. To examine the association of optimism and emotional responses during mental challenge, separate models were run for each emotion during mental challenge (i.e. interested, anxious, frustrated, irritated, depressed, and angry) the hierarchical regression model included 3 sets. The first set entered group status (healthy control, CAD, or ICD+CAD), the second set examined optimism, and the third set included the interaction between optimism and group status. Emotional responses to mental challenge were the dependent variables and separate analyses were conducted for the anger recall and mental arithmetic tasks.

Hypothesis 2. To examine the association of optimism and cardiovascular responses (SBP, DBP, and HR) during mental challenge initial analyses included a hierarchical linear regression model with 3 sets. The first set entered group status (healthy control, CAD, or ICD+CAD), the second set included optimism, and the third set examined the interaction between optimism and group status. An additional regression model was used to determine whether the relationship between optimism and hemodynamic response from baseline was independent of disease severity or other risk factors. Additional control variables entered into the regression model included demographic variables of age and gender;

cardiovascular risk factors of smoking history, hypertension, diabetes, peripheral vascular disorder (PVD), and body mass index (BMI); disease severity markers of angina, dyspnea, and ejection fraction; and baseline SBP DBP or HR. Separate analyses were conducted for SBP, DBP, and HR.

Hypothesis 3. To examine whether reduced cardiovascular responsiveness among optimistic individuals (H2) was mediated by attenuated emotional response to mental challenge (H1) the emotional response was included as an additional control variable to the hierarchical linear regression model conducted for H2. Consistent with H1, separate analyses were conducted for each emotion; anxious, frustrated, irritated, depressed, and angry. To reduce statistical type I error in testing H3, only those emotions were examined that significantly predicted SBP, DBP, or HR in H1, were added to the regression model used in H2. The emotional reaction was considered to mediate the relationship between optimism and cardiovascular responsiveness if the emotional reaction accounted for a significant amount of the variance beyond that accounted for by optimism.

Sample Size and Power Calculations

To determine the sample size needed for this study, power analyses were conducted with Type I error (alpha level) set at 0.05, the number of variables in the regression model was set at 3 for Hypothesis 1, and 3 for the initial regression model of Hypothesis 2. The number of variables was set at 10 for the second full regression model for Hypothesis 2, and at 11 for Hypothesis 3. The effect size needed to achieve 80% power was calculated for 20, 30, 40, 50, and 60 participants (see Table 2). These data indicate that the proposed study will be able to detect moderate effect sizes (0.19 – 0.47) at an alpha level of 0.05 with a power of 80%. All power analyses were performed with the nQuery Advisory power calculation software package.

RESULTS

Sample characteristics for demographics, cardiovascular risk factors, disease severity indicators, and baseline hemodynamics are presented in Table 1. The sample consisted of 50 healthy controls, 31 CAD patients, and 44 CAD patients with ICDs (see Table 1). The healthy controls were 56.0% male, with a mean age of 54.7 ± 10.9 years, 92% Caucasian, 8.0% African American, Hispanic or other ethnicity. The CAD patients were 74.2% male, had a mean age of 61.7 ± 7.9 years, and 77.4% were Caucasian, 22.6% were African American, Hispanic or other ethnicity. The CAD + ICD patients were 93.2% male, with a mean age of 60.7 ± 10.0 years, and 90.9% were Caucasian, 9.1% were African American, Hispanic or other ethnicity. The healthy control group contained significantly more women than both the CAD and CAD+ICD groups. As expected, healthy controls had significantly fewer known risk factors for cardiovascular disease than either of the diseased groups. Specifically healthy participants displayed less smoking behavior (both past and present), less diabetes mellitus, as well as lower baseline SBP, DBP, and HR.

Means and standard deviations for LOT total score, LOT positive and negative items, and filler items for each group are presented in Table 3. There were no differences in LOT scores between the groups. Mean LOT total score for Healthy controls was 22.72 ± 5.18, for CAD patients was 22.68 ± 5.50, and for ICD patients was 21.59 $\pm$ 5.49. These values are not significantly different from the momative LOT data (p's > 0.10).

Hypothesis 1. Optimism will be associated with lower negative emotional responses during mental challenge tasks

Emotional reactivity scores to mental challenge are presented in Table 4. The data demonstrate that mental stress produced a significant increase in all 5 emotions assessed across the three participant groups. Correlations between mood and optimism were conducted within each of the participant groups (see Table 5). Baseline moods were not correlated with optimism in any of the three groups. Optimism was correlated inversely with depressed, frustrated, and anxious emotions during the mental arithmetic task and with anger during the anger recall task for the healthy controls. For CAD patients, optimism was correlated with depressed and angry emotions during the anger recall task, and no significant correlations between optimism and mood were found in the ICD patients.

To examine the association of optimism and emotional responses during mental challenge a hierarchical linear regression model with 3 sets was conducted for each emotion (i.e. depressed, angry, frustrated, anxious, and irritated) during each of the mental challenge tasks. The first set examined the effect of group status (healthy control, CAD, or ICD+CAD); the second set examined the effect of optimism; and the third set examined the interaction between optimism and group status. Of the 5 regression models conducted for the mental arithmetic task a significant relationship between optimism and emotional reactivity was found in one model, specifically for depression. Of the 5 regression models conducted for the anger recall task significant relationships were found in 3 of the models, specifically for depression, anger, and frustration. Thus the results reveal that depression ratings were related to optimism during both the anger recall (R^2 $Change_{optimism}$ =0.10; F (3,118)=15.06; p<0.001) and mental arithmetic (R^2 $Change_{optimism}$ =0.07; F (3,118)=9.51; p=0.003) tasks. Anger and frustration ratings were significantly related to optimism for the anger recall task (R^2 $Change_{optimism}$ =0.05; F (3,118)=5.75; p=0.02), (R^2 $Change_{optimism}$ =0.05; F (3,118)=6.7; p=0.01) respectively, but not for the math task (R^2 $Change_{optimism}$ =0.001; F (3,118)=.09; p=0.77), (R^2 $Change_{optimism}$ <.001; F (3,118)=.01; p=0.91) respectively.

Hypothesis 2: Optimism will be associated with lower cardiovascular reactivity (SBP, DBP, and HR) during mental challenge tasks (define as difference between peak and baseline levels).

Analyses examining SBP, DBP, and HR for the anger recall task will be presented first, followed by the hemodynamics for the math task. Mean baseline and peak SBP, DBP, and HR scores are presented in Table 6. The data demonstrate that mental stress produced a significant increase in SBP, DBP, and HR from baseline to peak in both anger recall and mental arithmetic tasks assessed across the three participant groups. Correlations between optimism and hemodynamic reactivity during baseline, and during both the anger recall and mental arithmetic tasks are shown in Table 7. Reactivity (e.g. change score) was defined as arithmetic change score from baseline to peak level during the mental challenge tasks. Table 7 demonstrates that SBP was significantly positively correlated with optimism in the ICD patients and an inverse relationship was observed in healthy controls which approached significance ($p<0.07$). No relationship between optimism and SBP was found in CAD patients. This indicates that the relationship may be centrally mediated rather than at the hemodynamic level.

<u>Anger Recall and Cardiovascular Reactivity</u>

Hierarchical linear regression models were conducted for each reactivity outcome (i.e. SBP, DBP, and HR) by mental challenge task. Three sets were analyzed for each model: the first set entered group status (healthy control, CAD, or ICD+CAD), the second set was optimism, and the third set examined the interaction between optimism and group status.

Anger Recall and SBP Reactivity

As shown in Table 8, analyses of the SBP reactivity in response to the anger recall task revealed a significant interaction between group status and optimism level (R^2 Change$_{interaction}$ =0.06; $F(5,119)=3.98$; $p=.02$). Analysis of simple effects indicated differential reactivity within each group (see Figure 4). In the control group optimism was negatively associated with SBP reactivity ($r = -0.25$, $p= .08$) suggesting that in controls more optimistic individuals showed less SBP reaction (mean = 27.59, $\pm$ 18.41) during the anger recall challenge. There was no association between optimism and SBP reactivity) in CAD patients (mean = 36.77 $\pm$ 17.61; $r = .01$, $p=.97$). In contrast, optimism was positively associated with SBP reactivity in patients with ICDs (mean = 37.51 $\pm$ 16.41; $r = .34$, $p=.03$)

indicating that more optimistic individuals demonstrated increased SBP reaction during the task. There was also a significant main effect of group status (R^2 $Change_{group}$ =0.07; F (2,122)=4.53; p=0.013) on SBP reactivity indicating higher SBP reactivity among ICD and CAD patients than healthy controls, whereas no significant main effect was observed for optimism (R^2 $Change_{optimism}$ <0.001; F (3,121)=.012; p=0.91). Therefore the disease related reactivity had a greater effect than optimism.

Anger Recall and DBP Reactivity

Means and standard deviations for DBP reactivity during the anger recall task are as follows; healthy controls (mean = 16.41 $\pm$ 10.21), CAD patients (mean = 18.58 $\pm$ 8.59), and ICD patients (mean = 21.02 $\pm$ 7.14). The regression model conducted as stated above for DBP reactivity revealed a significant main effect relationship for group status, (R^2 $Change_{group}$ =0.05; F (2,122)=3.19; p=0.04) but not for optimism (R^2 $Change_{optimism}$ =0.01; F (3,121)=1.18; p=0.27) or the interaction of optimism and group status (R^2 $Change_{interaction}$ =0.01; F (5,119)=.85; p=.43; see Table 9).

Anger Recall and HR Reactivity

Means and standard deviations for HR reactivity during the anger recall task are as follows; healthy controls (mean = 14.03 $\pm$ 9.72), CAD patients (mean = 10.40 $\pm$ 7.22), and ICD patients (mean = 11.53 $\pm$ 7.87). Regression model conducted as stated above for HR reactivity revealed no significant effects for group (R^2 $Change_{group}$ =0.03; F (2,122)=1.98; p=0.14); optimism (R^2 $Change_{optimism}$ =0.01; F (3,121)=.05; p=0.82), and no significant interaction (R^2 $Change_{interaction}$ =0.01; F (5,119)=.41; p=.67) (Table 10).

Anger Recall Reactivity Adjusted for Covariates

Three additional regression models were conducted in which covariates were added to each reactivity model to examine whether the significant interaction was attributable to other variables. The following covariates were added; step 1 included demographic variables of age and gender; step 2 included cardiovascular risk factors of smoking history, BMI, hypertension, diabetes, peripheral vascular disorder; step 3 included disease severity markers of angina, dyspnea, and ejection fraction; and step 3 included baseline SBP.

As displayed in Table 11, in the fully adjusted model the interaction of group status x optimism contributed significantly to predict SBP during the anger recall task (R^2 $Change_{interaction}$ =0.05; F (15,103) =3.90; p=.02). The main effect of group status was also retained (R^2 $Change_{group}$ =0.09; F (12,106) =6.39; p=.002), and no significant main effect was observed for optimism (R^2 $Change_{optimism}$ =0.01; F (13,105)=.14; p=0.71) in the fully integrated model (see Table 11). Similarly, after adjusting for covariates, the relationship between DBP and group status, optimism and the interaction were nonsignificant (see Table 12). After adjusting for covariates, the relationship between HR and group status, optimism and the interaction were nonsignificant (see Table 13).

<u>Mental Arithmetic and Cardiovascular Reactivity</u>

Mental Arithmetic and SBP Reactivity

The same pattern of results was found for systolic blood pressure reactivity for the mental arithmetic task. The hierarchical linear regression model with 3 sets revealed a marginally significant interaction between group status and optimism level (R^2 Change$_{interaction}$ =0.04; F (5,119) =2.79; p= .06) indicating that for the patients with ICDs, optimism was positively associated with SBP reactivity (mean = 45.15 ± 17.90; r = .26, p=.08). The relationship between optimism and SBP reactivity during the math task for controls was in the expected direction but not significant (mean = 32.51 ± 17.24; r = -0.21, p= .11) and optimism was not significantly related to change in SBP among CAD patients (mean = 44.09 ± 19.24; r = .12, p=.37). As shown in Table 14, there was a significant main effect of group status (R^2 Change$_{group}$ =0.10; F (2,122) =6.91; p=0.001) on SBP reactivity, whereas no significant main effect was observed for optimism (R^2 Change$_{optimism}$ =0.01; F (3,121)=.44; p=0.51).

Mental Arithmetic and DBP Reactivity

Means and standard deviations for DBP reactivity during the mental arithmetic task are as follows; healthy controls (mean = 16.85 ± 9.66), CAD patients (mean = 21.22 ± 12.74), and ICD patients (mean = 22.66 ± 7.98). The regression model conducted as stated above for DBP reactivity revealed a significant main effect relationship group status, (R^2 Change$_{group}$ =0.07; F (2,122) =4.27; p=0.02) but not for optimism (R^2 Change$_{optimism}$ =0.01; (3,121)=..16; p=0.69) or the interaction of optimism and group status (R^2 Change$_{interaction}$ =0.02; F (5,119) =1.48; p=.23) (see Table15).

Mental Arithmetic and HR Reactivity

Means and standard deviations for HR reactivity during the mental arithmetic task are as follows; healthy controls (mean = 15.81 ± 12.62), CAD patients (mean = 12.30 $\pm$ 7.70), and ICD patients (mean = 14.33 $\pm$ 8.74).The regression model conducted as stated above for HR reactivity revealed no significant effects for group (R^2 $Change_{group}$ =0.02; F (2,121) =1.12; p=0.33); optimism (R^2 $Change_{optimism}$ =0.01; F (3,120)=.10; p=0.75); or the group by optimism interaction (R^2 $Change_{interaction}$ =0.01; F (5,118)=.11; p=.90) (see Table 16).

Mental Arithmetic Reactivity Adjusted for Covariates

Three additional regression models were conducted in which covariates were added to each reactivity model to examine whether the significant interaction was attributable to other variable. The following covariates were added; step 1 included demographic variables of age and gender; step 2 included cardiovascular risk factors of smoking history, BMI, hypertension, diabetes, peripheral vascular disorder; step 3 included disease severity markers of angina, dyspnea, and ejection fraction; and step 3 included baseline hemodynamics.

As seen in Table 17, the interaction of group status x optimism contributed significantly to predict SBP during the mental arithmetic task (R^2 $Change_{interaction}$ =0.05; F (15,103) =3.16; p=.05). Main effect of group status was also retained (R^2 $Change_{group}$ =0.10; F (12,106)=6.45; p=.002), and no main effect for optimism was observed (R^2 $Change_{optimism}$ =0.01; F (13,105)=.15; p=0.70. After adjusting for covariates, the relationship between DBP and group status, optimism and the interaction were nonsignificant (see Table 18).

Similarly, after adjusting for covariates, the relationship between HR and group status, optimism and the interaction were nonsignificant (see Table 19).

Exercise and SBP Reactivity

Hemodynamic reactivity was also measured during exercise. As in the mental challenge tasks, reactivity was evaluated as arithmetic change scores from baseline to peak level during the exercise task. Because there were differences in the TRIAD and CARES studies exercise protocols, only TRIAD data was analyzed. Specifically, task reactivity was defined as the peak hemodynamic response during the task subtracted from an average of three measurements of hemodynamic measures during the rest period. SBP means and standard deviations during the exercise task are presented in Table 20. Analyses reveal that SBP responses during the exercise task were not related to optimism levels for healthy controls, $r=-0.22$, $p.=0.29$; CAD patients, $r=-0.08$, $p=0.73$, or ICD patients, $r=0.16$, $p.=0.31$. Further, SBP responses to exercise were not significantly related to SBP response to the mental challenge tasks in the healthy controls (anger recall; $r=-0.09$, $p.=0.67$, mental arithmetic $r=0.01$, $p=0.95$), and ICD patients (anger recall; $r=0.19$, $p.=0.22$, mental arithmetic $r=0.23$, $p<0.13$). Correlations among CAD patients were significant for math ($r=0.70$, $p.=0.002$), but not anger recall ($r=0.41$, $p=0.10$). The data indication that optimism is not associated with SBP response to physical challenge.

Hypothesis 3. The reduced cardiovascular responsiveness among optimistic individuals is mediated by the attenuated emotional response to mental challenge.

In order to examine the relationship between emotional responsiveness and hemodynamic responses across patient groups and tasks, correlations between mood and hemodynamic response were conducted (see Tables 21, 22, and 23). The data reveal no significant correlations between baseline emotion and baseline SBP, DBP, or HR in any of the three groups. Healthy controls did demonstrate a significant relationship between baseline anxiety and SPB reactivity during the mental arithmetic task, but no other significant relationships were found between baseline emotions and hemodynamic reactivity for any of the three groups during either of the mental challenge conditions. Among ICD patients significant correlations were found between emotions and peak SPB and DBP scores, but not for SBP or DBP baseline or reactivity scores.

Anger Recall and SBP Reactivity Mediational Model

Consistent with examining a mediational model, analyses of the SBP reactivity in response to the anger recall task revealed a significant interaction between group status and optimism level, whereas no such interaction was observed for DBP and HR (see Table 8). Hypothesis 3 will therefore primarily focus on the role of emotional reactivity in SBP responses to mental challenge. To examine whether the association of optimism and SBP responses during mental challenge was mediated by emotional response, a hierarchical linear regression model with 4 sets was analyzed: the first set entered group status (healthy control, CAD, or ICD+CAD), the second set examined emotional response to the challenge task, the third set examined optimism, and the fourth set examined the interaction between optimism and group status. Consistent with H1, separate analyses were conducted for each emotion depressed, frustrated, and angry. As shown in Tables 24- 26, effects of the emotional response on SBP reactivity in response to the anger recall task were not significant for any of the emotional reactivity variables suggesting that SBP reactivity was not mediated by frustrated (R^2 Change$_{frustrated}$ F (2,119)<0.001; p=.81) (see Table 24), depressed (R^2 Change$_{depressed}$ F (2,119)=0.001; p=.80) (see Table 25); or angry emotion (R^2 Change$_{angry}$ F (2,119)=0.001, p=.71) (see Table 26).

Mental Arithmetic and SBP Reactivity Mediational Model

Analysis of the SBP reactivity during the mental arithmetic task also revealed no significant relationship with emotional reactivity. As shown in Tables 27-29, emotional reactivity variables did not account for additional variability, frustrated (R^2 Change$_{frustrated}$ F (2,119)=0.01; p=.37) (see Table 27), depressed (R^2 Change$_{depressed}$ F (2,119)=0.002; p=.09) (see Table 28); angry (R^2 Change$_{angry}$ F (2,119)=0.01, p=.18) (see Table 29).

Discussion

This study examined whether optimism is associated with reduced emotional and cardiovascular reactivity to mental challenge. Participants' physiological and emotional levels were obtained at baseline and during two mental challenge tasks. Optimism was associated with beneficial effects among healthy participants, including reduced negative emotional responses to mental challenge and lower systolic blood pressure reactivity. However, these associations were not observed in patients with coronary artery disease, and optimism was associated with increased pressor responses in the CAD patients with arrhythmic vulnerability (i.e., patients with an implantable cardioverter defibrillator). Thus, the biobehavioral mechanisms by which optimism may affect the cardiovascular system may vary with the presence or severity of underlying coronary artery disease.

The Relationship between Optimism and Emotional Reactivity

The present observations are consistent with previous research and add to this literature that disease severity may modify the relationship between optimism with stress-induced reactivity. Healthy individuals who were optimistic had lower levels of negative emotions of depression, anger, frustration, and anxiety during the mental challenge tasks but not at baseline. Optimistic participants with CAD also demonstrated lower levels of depressed and angry emotions in response to challenge tasks. These data suggest that the task-induced emotional *responses* were attenuated among optimistic participants, and that these associations do not reflect a baseline response set to report less negative emotions. These relationships were primarily observed in the more intense emotions, i.e., anger and depressed mood, and not in other responses of being interested, irritated, etc. These data differ from observations in healthy individuals by Raikkonen and colleagues (1999), reporting that emotional reports at baseline were associated with optimism. One of the explanations for this discrepancy could lie in the laboratory setting of the present study, versus the ambulatory mood assessments in the study by Raikkonen et al., (1999). The latter design in daily life settings may not be optimal to assess physiological arousal in a defined resting condition. The results for the healthy and CAD participants are consistent with research that suggests that optimists have lower levels of negative emotions of depression, anxiety, and anger in response to adverse challenges (Carver & Scheier, 1994).

More severely diseased CAD patients with arrhythmic vulnerability did not reveal an association between optimism and lower levels of negative emotions in response to the mental challenge tasks. This observation may be related to the burden of chronic illness in these patients. Research consistently supports that patients with cardiovascular disease are more likely to be depressed and anxious than age-matched healthy controls (Rozanski & Kubzansky, 2005). It is possible that the relationship of disease severity and negative emotions contributes to the prolonged activation of negative emotional reaction of optimistic individuals in ICD patients.

The Role of Optimism in Hemodynamic Reactivity to Mental and Physical Challenge Tasks.

Hemodynamic responses to the mental challenge tasks revealed a significant inverse relationship with optimism in healthy individuals. As hypothesized, higher levels of optimism among healthy participants were related to lower SBP responses to the mental challenge tasks. The reduced hemodynamic response among the high-optimistic healthy controls to mental challenge is consistent with findings of Raikkonen and colleagues (1999). These investigators documented that optimism among healthy men and women was associated with lower average SBP and DBP during daily life activities. Although there were group differences at baseline, relationships between DBP and HR with optimism were not significant for any of the three groups in the present study.

The relationship between optimism and SBP was only observed during the challenge tasks and not during resting conditions. This finding is in contrast with previous research suggesting that optimistic individuals have lower blood pressure levels overall than their pessimistic counterparts (Raikkonen et al., 1999). However, it is important to note one key difference between this study and previous research conducted by Raikkonen and colleagues (1999). As mentioned, Raikkonen and colleagues conducted a study that assessed ambulatory blood pressure throughout the day, including during interpersonal interaction at work and at home, whereas the present study assessed blood pressure while the participant was resting quietly in the laboratory prior to the challenge tasks. Participants' hemodynamics may not have been aslow as true baseline levels because they were aware that they would be engaging in stressful at the completion of the rest period. Secondly, only healthy individuals participated in the Raikkonen et al., (1999) study and there are no data suggesting whether the same relationships would be found with patients having cardiovascular disease.

Optimism and cardiovascular responses were not significantly related in the CAD patients and showed an unanticipated reverse pattern in ICD patients. There could be a number of reasons for the diverging findings between the healthy participants and the ICD patients. These include: (1) task perception; (2)

concurrent personality traits such as hostility; (3) differential tendencies to provide socially desirable responses; and (4) biological constraints in the diseased individual.

1. Group differences in task perception may be one potential explanation for the failure to find decreased cardiovascular reactivity among optimistic ICD patients. The pessimistic individuals may have expected the tasks to be unpleasant. Finding no discrepancy between their expectations and experience of the task, the sympathetic nervous system arousal to elicit changes in the heart rate and blood pressure may not have occurred. Further, ICD patients are aware of the possibility of acute stress experiences triggering a discharge of the ICD, delivering a painful electric shock. Because optimistic individuals are known to engage in more active coping skills (Scheier and Carver, 1989; 1999), it is possible that the optimistic patients are more attuned to their physiological reactions and the possible consequence of an ICD discharge. Being unable to use active coping to avoid the stressor and subsequent physiological, hemodynamic reactivity, the increased awareness of this additional stressor may have inflated the cardiovascular response in optimistic ICD patients. However, the ICD group did not express significantly lower level of interest, or higher level of anxiety at baseline or during the mental challenge tasks (Table 4). These observations suggest that altered task perception or elevated cardiovascular reactivity do not account for the paradoxical association between optimism and increased SBP reactivity in ICD patients.

2. Stable personality traits other than optimism may have played a mediating role in the present observation of elevated SBP reactivity among optimistic ICD patients. Hostility has been postulated to be associated with cardiovascular reactivity in cardiovascular disease patients as well as healthy controls. In addition, hostility is also associated with increased risk of CAD. Thus, it is possible that the observed relationship between optimism and cardiovascular reactivity may have been influenced by elevated hostility levels among ICD patients. The mean hostility scores for the three groups were as follows: healthy controls15.4, +/- 6.9, CAD16.2, +/- 10.3, and ICD 16.3, +/- 6.9. Exploratory correlation analyses revealed an inverse relationship between hostility as measured by the Cook-Medley Hostility Inventory (Cook & Medley, 1954) and optimism (r=-0.29, p.=0.01), indicating that optimism was associated with lower hostility levels. Analysis per group revealed that there was no significant relationship between hostility and optimism in the healthy participants (r= -0.02, p.=0.93) or the CAD patients (r= -42, p.=0.12) whereas the correlation was significant in the ICD group (r= -0.39, p.=0.01). The lower hostility scores demonstrated by optimistic ICD patients suggest that underlying hostility levels are not likely to be responsible for the increased cardiovascular response in these patients.

3. Another possible explanation that may have contributed to the elevated SBP reactivity among optimistic ICD patients is the potential for biases related to performance components of the mental challenge tasks. The physiological effects elicited by these tasks may be more prone to influenced by concern

regarding the participants' evaluation by others (Schwartz, 2003). Greater self reported optimism may be associated with social desirability. Socially desirable response tendencies may prompt more optimistic ICD patients to report greater emotional reactivity in the presence of the investigator and to more actively engage in the tasks with subsequent elevations in cardiovascular reactivity. This explanation is unlikely because this emotional responsiveness and optimism levels did not significantly differ between patients and controls. Therefore, other biobehavioral processes may be responsible for the present findings.

4. Finally, it is possible that selective survival may have influenced the relationship between optimism and cardiovascular reactivity. Little is known about the changes in optimism level as individuals age, or progress through chronic illnesses. It is possible that young and healthy individuals with optimism levels diminish when faced with chronic illness. As current data showed there were no differences between the groups on optimism scores, it may be that the diseased groups had significantly higher optimism scores if optimism scores would have been assessed before the onset of cardiovascular disease. Because optimism levels have been shown to predict cardiovascular events and mortality (Kubzansky, 2001; Helgeson, 1999, 2004; Giltay, 2001, 2006), it is possible that the least optimistic individuals have died before reaching the most advanced stages of cardiovascular disease. Therefore, individuals in the ICD group may represent a select group consisting of only individuals with initially high levels of optimism. The hemodynamic functioning may consequently be substantially better than the level of disease severity would predict.

Analysis of Mediational Model

Emotional reactivity did not mediate the relationship between optimism and cardiovascular response to mental challenges in either healthy or diseased participants. This investigation found associations between negative emotions and cardiovascular reactivity (Tables 21-23) and optimism was also correlated to emotional response to the task (Table 5). However, emotional reactivity did not account for the relationship between optimism and hemodynamic responsiveness. Therefore, although the proposed model does demonstrate that there is an effect of optimism on emotional as well as hemodynamic responses to a stressor, it is unlikely that the emotional responses account for the relationship between optimism and cardiovascular reactivity.

Limitations of the Current Study

A few methodological issues may limit the conclusions that can be drawn from this study. The study population contained comparable percentages of men and women in the control group, whereas the CAD and the ICD groups consisted of considerably more men than women. Other investigations examining optimism is cardiac patients included only of men (Scheier and Carver 1989; Kubzansky, 2001; and Giltay, 2006) and studies that have examined differences between men and women documented stronger cardiovascular health protective effects of optimism for men than for women (Giltay, 2006). Several analyses were conducted using data collected on only the men in this study in an attempt to address possible differenctial results by gender. The analyses revealed no systematic differences in the results of men only compared to the results obtained examining the entire sample of men and women. As a result of the small number of women in the present sample, analyses of women only were not explored in the present study.

Another limitation of this study pertains to the fact that analyses were based on two existing studies, and as such the two larger studies were not specifically designed for the purposes of the hypotheses in the present study. In the TRIAD study, optimism scores were assessed on the same day as the laboratory visit, whereas in the CARES protocol optimism scores were obtained at the 8 month follow-up. Although, by definition, optimism scores are stable over time, it is possible that the circumstances under which the optimism scores were collected produced systematic differences beween the TRIAD and CARES participants although no differences were found between mean optimism scores in TRIAD and CARES participants. Further, the emotional reactivity was measured following the completion of both mental challenge tasks. This may not have optimally assessed the participant's emotions for the anger recall task, and may partially reflect a cumulative effect of both tasks. However we did observe significant associations between emotional responses and cardiovascular reactivity in the healthy and ICD groups suggesting that we were in the position to examine the purported mediational model (H3).

An additional limitation of laboratory investigations is lack of opportunity to assess the frequency of the stress response as it occurs in daily life settings. It may be that optiimistic individuals have a higher threshhold for activation of the stress response, and therefore, cardiac benefits may not only be related to the magnitude of the stress response, but also to the frequency of its activation. Furture investigations may seek to further investigate this hpothesis using ambulatory methods in both healthy and diseased populations to accurately quantify participants' frequency of stress experience.

Clinical Implications

Despite the limitations of the present investigation, the findings provide important information on the role of optimism in cardiovascular responsivness to an acute stressor. Previous work in this area has been conducted primarily with healthy individuals. The present investigation supports previous findings in healthy individuals. However, divergent results in the most severely diseased cardiac patients provide important information on the generalizabilty of previous results. By providing preliminary findings for cardiac patients, interventions may be tailored to the specific outcome measures most salient to such patients. Although optimism interventions have demonstrated ability to increase optimism scores in healthy adolescents (Chang, 2001) and breast cancer patients (Antoni, 2001) research of specific optimism interventions in cardiac patients is currently lacking. The wealth of research demonstrating improved health outcome in cardiac patients implies that cardiac patients would also benefit from incorporating an optimism intervention into existing cardiac rehabilitation programs. However, as it appears that optimism does not attenuate emotional and cardiovascular responses to acute stressors among ICD patients, current interventions such as biofeedback, and stress and anger management, and hypertension medications may remain essential elements of psychosocial cardiac rehabilitation programs for high risk patients.

Future Directions

Promising approaches for future research include efforts at replicating the finding that optimism predicts SBP response to acute challenges in healthy and diseased individuals, and determining the extent to which this relationship predicts responses to challenges and hassles in daily life. In conjunction with the finding that emotional reactivity did not appear to mediate the relationship between optimism and cardiovascular reactivity, further clarification of the mechanisms of that relationship would be beneficial regarding the clinical efforts aimed at developing stress and anger management interventions, particularly for those individuals already diagnosed with CAD.

Another critical direction for future research efforts is examining the effects of disease on optimisic fluctuations. It is unknown whether individual's optimism level undergoes enduring changes or fluctuations as an individual ages or progresses through stages of chronic illness. Although, there have been prospective studies demonstrating that optimism level predicts future morbidity and mortality (Kubzansky et al,. 2001; Scheier and Carver, 1989, 1999; Hegelson, 1999, 2003; Giltay, 2001, 2006), these studies have only assessed optimism at one time point, either while the individuals were still disease free, or following and throughout a diagnosis of a chronic illness. Very few studies have assessed optimism at multiple points of time. It is reasonable to assume that optimism scores do systematically fluctuate as ones life circumstances change.

If optimism scores do tend to vary over the course of an individual's lifetime, it would be beneficial to document the predictive value of optimism score when the individual is healthy versus situations in which a diagnosis with a chronic illness is present.

Finally, future research may focus on other pathways by which optimism can cause health benefits. There are a wide range of related variables that possess similar relationships with optimism, with regard to their impact on health. Continuing scrutiny of variables such as coping style, self efficacy, depression, social support, and engagement in health behaviors could serve to increase understanding of the causal mechanisms underlying heart disease development and improved health outcomes of optimistic individuals. This information will be very beneficial in determining the nature of and developing appropriate psychological interventions for cardiac patients.

Table 1: Sample characteristics

	Healthy Controls (N=50)	CAD (N=31)	CAD+ICD (N=44)	F or X^2	p
Male	28 (56.0%)	23 (74.2%)**	41 (93.2%)**	X^2 =16.7	0.001
Age years (SD)	54.74 (10.93)	61.71 (7.99)**	60.77 (9.97)**	F=6.35	0.002
BMI kg/m2 (SD)	25.82 (4.17)	29.74 (4.56)**	28.05 (4.07)*	F=8.51	0.001
Caucasian	46 (92%)	24 (77.4%)	40 (90.9%)	X^2 =14.0	0.083
African American Hispanic, Asian or other	4 (8.0%)	7 (22.6%)	4 (9.1%)		
Smoke currently	6 (12.0%)	4 (13.8%)	5 (11.46%)	X^2 =25.95	0.001
History	16 (32.0%)	20 (69%)**	32 (72.7%)**		
Never	28 (56.0%)	5 (17.2%)**	5 (11.4%)**		
Hypertension	33 (66.0%)	17 (54.8%)	24 (55.8%)	X^2 = 1.4	0.50
Diabetes Mellitus	0	7 (22.6%)**	13 (29.5%)**	X^2 =16.5	0.001
PVD	1 (2.0%)	2 (6.7%)	6 (14.0%)*	X^2 =4.86	0.086
EF >50%	50	17 (54.8%)**	4 (9.1%)**	X^2=88.3	0.001
EF 30%-50%	0	8 (25.8%)**	23 (52.3%)**		
EF <30%	0	6 (19.4%)**	17 (28.6%)**		
Angina (NYHA III-IV)	0	1 (6.3%)	2 (4.5%)	X^2 =5.2	0.21
Dyspnea (NYHA III-IV)	0	1 (6.3%)	1 (2.3%)	X^2 =8.49	0.075
BL SBP (SD)	120.61 (15.13)	136.26 (18.1)**	132.14 (22.97)**	F=7.784	0.001
BL DBP (SD)	73.31 (8.15)	78.88 (11.51)*	77.31 (10.66)	F=3.49	0.034
BL HR (SD)	66.07 (10.17)	58.38 (10.06)**	64.03 (9.64)	F=5.825	0.004

Note: BMI= Body Mass Index; PVD=Peripheral Vascular Disease; EF= Ejection Fraction; NYHA = New York Heart Association classification; BL SBP=Baseline Systolic Blood Pressure; BL DBP=Baseline Diastolic Blood Pressure; BL HR=Baseline Heart Rate; * p.<.05, ** p < 0.01 compared to controls

Table 2: Power Estimates for Hypotheses 1, 2, and 3

Number of participants (per cell)	20	30	40	50	60
Effect size (R^2) for 3 variables	0.41	0.30	0.23	0.19	0.16
Effect size (R^2) for 4 variables	0.44	0.32	0.25	0.21	0.18
Effect size (R^2) for 10 variables	0.65	0.45	0.35	0.29	0.24
Effect size (R^2) for 11 variables	0.68	0.47	0.37	0.30	0.25

Table 3: Means and Standard Deviations for Life Orientation Test Scores

	Healthy Controls		CAD		CAD + ICD	
	(N=50)		(N= 31)		(N= 44)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
LOT Total	22.72	(± 5.18)	22.68	(± 5.50)	21.59	(± 5.49)
Positive Items Total	11.26	(± 2.97)	11.19	(± 2.77)	10.80	(± 3.20)
Negative Items Total	4.54	(± 3.28)	4.52	(± 3.34)	5.20	(± 3.08)
Filler items	12.16	(± 2.08)	11.77	(± 1.89)	10.45	(± 2.63)

Table 4: Emotional Reactivity

		Healthy Controls (N= 47)		CAD (N= 31)		CAD + ICD (N= 44)	
		Mean Baseline	Mean Peak	Mean Baseline	Mean Peak	Mean Baseline	Mean Peak
Depressed	AR	1.19	1.66 **	1.47	1.90 **	1.26	2.00 **
	MA	1.19	1.66 **	1.47	2.03 **	1.26	1.95 **
Angry	AR	1.19	3.66 **	1.17	3.84 **	1.42	3.95 **
	MA	1.19	2.66 **	1.17	4.10 **	1.42	2.98 **
Frustrated	AR	1.30	3.26 **	1.37	4.06 **	1.58	3.64 **
	MA	1.30	5.06 **	1.37	5.48 **	1.58	4.84 **
Anxious	AR	2.32	3.38 **	2.37	3.74 **	2.6	3.27 **
	MA	2.32	4.72 **	2.37	4.90 **	2.6	4.27 **
Irritated	AR	1.32	3.91 **	1.53	4.06 **	1.67	3.75 **
	MA	1.32	4.28 **	1.53	4.77 **	1.67	3.68 **

Note: AR=Anger Recall; MA=Mental Arithmetic; * = $p<.05$, **=$p<0.01$

Table 5: Correlations Between Emotional Reactivity and Optimism

		Healthy Controls (N= 47) Correlation	CAD (N= 31) Correlation	CAD + ICD (N= 44) Correlation
Depressed	BL	-.16	-.24	.07
	AR	-.25	**-.71****	-.21
	MA	**-.38****	-.24	-.02
Angry	BL	.01	.06	.07
	AR	**-.30***	**-.38***	-.00
	MA	.15	-.12	-.09
Frustrated	BL	.09	.14	.07
	AR	-.22	-.30	-.21
	MA	**-.30***	.16	.11
Anxious	BL	**-.32***	.09	.07
	AR	-.25	.15	-.22
	MA	**-.41****	.16	-.02
Irritated	BL	-.02	-.19	.06
	AR	-.24	-.22	-.00
	MA	-.14	.20	-.02

Note: BL=Baseline; AR=Anger Recall; MA=Mental Arithmetic; * = p<.05, **=p<0.01

Table 6: Mean Baseline and Peak Hemodynamics

		Healthy Controls (N=50)		CAD (N= 31)		CAD + ICD (N= 44)	
		Baseline	Peak	Baseline	Peak	Baseline	Peak
SBP	AR	120.61	148.20 **	136.26	173.03 **	132.14	169.66 **
	MA	120.61	153.12 **	136.26	180.29 **	132.14	177.30 **
DBP	AR	73.31	89.72 **	78.88	97.45 **	77.31	98.34 **
	MA	73.31	90.16 **	78.88	100.10 **	77.31	99.98 **
HR	AR	66.07	80.10 **	58.38	68.77 **	64.03	75.57 **
	MA	66.07	81.88 **	58.38	70.67 **	64.03	78.09 **

Note: SBP=Systolic Blood Pressure; DBP=Diastolic Blood Pressure; HR=Heart Rate; AR=Anger Recall; MA=Mental Arithmetic; * = p<.05, **=p<0.01

Table 7: Hemodynamic Reactivity Correlations with Optimism

		Healthy Controls (N= 47) Correlation	CAD (N= 31) Correlation	CAD + ICD (N= 44) Correlation
SBP	BL	-.07	-.08	.02
	AR Δscore	**-.25^**	-.01	**.34***
	MA Δscore	-.21	.16	**.26^**
DBP	BL	.10	-.17	-.10
	AR Δscore	-.17	-.17	.07
	MA Δscore	-.24	-.06	.12
HR	BL	.10	-.05	-.03
	AR Δscore	-.01	.11	-.13
	MA Δscore	-.01	.14	-.01

Note: SBP=Systolic Blood Pressure; DBP=Diastolic Blood Pressure; HR=Heart Rate; BL=Baseline; AR=Anger Recall; MA=Mental Arithmetic; ^=p<0.10, * = p<.05, **=p<0.01

Table 8: SBP Reactivity to Anger Recall

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.069	4.53	.013	.069	4.53	**.013**
Optimism	.069	2.99	.033	.0001	.01	.913
Group x Optimism Interaction	.128	3.48	.006	.058	3.98	**.021**

Table 9: DBP Reactivity to Anger Recall

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.050	3.19	.044	.050	3.19	**.044**
Optimism	.059	2.53	.061	.009	1.18	.279
Group x Optimism Interaction	.072	1.85	.108	.013	.85	.428

Table 10: HR Reactivity to Anger Recall

Predictors	R^2	F	p	R^2 Change	F Change	F Change p value
Group status	.031	1.98	.142	.031	1.98	.142
Optimism	.032	1.33	.269	.000	.053	.819
Group x Optimism Interaction	.038	.95	.451	.007	.41	.667

Table 11: SBP Reactivity to Anger Recall Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.091	5.82	.004	.091	5.82	**.004**
Risk Factors (hypertension, IDDM, PVD, smoking, and BMI)	.141	2.61	.016	.050	1.30	.271
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.15	2.06	.040	.004	.24	.786
Baseline SBP	.149	1.88	.055	.003	.44	.510
Group status	.240	2.79	.002	.092	6.39	**.002**
Optimism	.241	2.57	.004	.001	.142	.707
Group x Optimism Interaction	.295	2.87	.001	.053	3.90	**.023**

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; SBP=Systolic Blood Pressure

Table 12: DBP Reactivity to Anger Recall Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.092	5.86	.004	.092	5.88	**.004**
Risk Factors (hypertension, IDDM, PVD)	.116	2.08	.052	.024	.60	.699
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.125	1.74	.089	.009	.59	.556
Baseline SBP	.140	1.76	.078	.014	1.80	.182
Group status	.165	1.74	.067	.025	1.60	.208
Optimism	.183	1.813	.050	.018	2.37	.127
Group x Optimism Interaction	.196	1.67	.068	.012	.79	.456

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; DBP=Diastolic Blood Pressure

Table 13: HR Reactivity to Anger Recall Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.091	1.14	.324	.019	1.14	.324
Risk Factors (hypertension, IDDM, PVD)	.077	1.32	.247	.058	1.39	.235
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.099	1.33	.231	.022	1.32	.271
Baseline SBP	.099	1.85	.309	.001	.009	.926
Group status	.104	1.02	.435	.005	.29	.753
Optimism	.106	.96	.497	.002	.28	.598
Group x Optimism Interaction	.117	.91	.551	.011	.67	.516

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; SBP=Systolic Blood Pressure

Table 14: SBP Reactivity to Mental Arithmetic

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.102	6.91	.001	.102	6.91	**.001**
Optimism	.105	4.73	.004	.003	.44	.511
Group x Optimism Interaction	.145	4.04	.002	.040	2.79	**.065**

Table 15: DBP Reactivity to Mental Arithmetic

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.065	4.27	.016	.065	4.27	**.016**
Optimism	.067	2.88	.039	.001	.16	.69
Group x Optimism Interaction	.089	2.34	.046	.023	1.48	.23

Table 16: HR Reactivity to Mental Arithmetic

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.018	1.12	.33	.018	1.12	.33
Optimism	.019	.77	.51	.001	.10	.75
Group x Optimism Interaction	.021	.50	.78	.002	.11	.90

Table 17: SBP Reactivity to Mental Arithmetic Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.06	3.76	.026	.06	3.76	**.026**
Risk Factors (hypertension, IDDM, PVD)	.07	1.43	.211	.01	.305	.874
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.082	1.24	.286	.011	.686	.506
Baseline SBP	.084	1.13	.350	.003	.321	.572
Group status	.188	2.27	.016	.103	.687	**.002**
Optimism	.189	2.08	.024	.001	.146	.703
Group x Optimism Interaction	.235	2.31	.008	.046	.318	**.046**

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; SBP=Systolic Blood Pressure

Table 18: DBP Reactivity to Mental Arithmetic Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.062	3.80	.025	.062	3.80	**.025**
Risk Factors (hypertension, IDDM, PVD)	.091	1.58	.147	.029	.72	.613
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.099	1.33	.231	.008	.48	.620
Baseline SBP	.116	1.41	.184	.017	2.07	.153
Group status	.147	1.53	.125	.032	1.97	.144
Optimism	.151	1.43	.157	.003	.39	.536
Group x Optimism Interaction	.179	1.49	.122	.028	1.75	.179

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; DBP=Diastolic Blood Pressure

Table 19: HR Reactivity to Mental Arithmetic Fully Adjusted Model

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Demographic Factors (age, gender)	.006	.32	.728	.006	.32	.728
Risk Factors (hypertension, IDDM, PVD)	.105	1.84	.087	.099	2.44	**.034**
Cardiac Disease Severity (ejection fraction, angina, dyspnea)	.106	1.42	.188	.001	.08	.928
Baseline SBP	.108	1.30	.24	.002	.26	.615
Group status	.114	1.12	.349	.006	.35	.709
Optimism	.114	1.03	.427	.0001	.05	.828
Group x Optimism Interaction	.118	.91	.555	.004	.22	.805

Note: IDDM=Insulin Dependent Diabetes Mellitus; PVD=Peripheral Vascular Disease; BMI=Body Mass Index; HR=Heart Rate

Table 20: SBP Means and Standard Deviations During Exercise

Systolic Blood Pressure	Healthy Controls (N=50)		CAD (N= 31)		CAD + ICD (N= 44)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
BL	66.62	(± 11.01)	58.84	(± 9.48)	63.36	(± 9.75)
Exercise Stage 1	101.92	(± 43.40)	107.19	(± 43.28)	145.82	(± 30.33)
Exercise Stage 2	129.20	(± 31.87)	133.00	(± 29.73)	157.79	(± 28.84)
Exercise Stage 3	135.57	(± 28.32)	141.00	(± 26.11)	153.5	(± 20.23)
Exercise Stage 4	145.21	(± 15.23)	153.06	(± 27.50)	150.86	(± 22.89)

Note: BL=Baseline

Table 21: Emotional Reactivity Correlations with SBP Reactivity

		Healthy Controls (N= 47) Correlation			CAD (N= 31) Correlation			CAD + ICD (N= 44) Correlation		
		BL	SBP Max	SBP Δ	BL	SBP Max	SBP Δ	BL	SBP Max	SBP Δ
Depressed	BL	.16			.07			-.12		
	AR		.07	-.05		.23	-.03		**.37***	.11
	MA		.23	.23		.07	-.08		**.31***	-.01
Angry	BL	.01			-.11			-.12		
	AR		.08	.05		.07	-.11		**.42****	.13
	MA		.09	-.21		-.31	-.35		.02	.00
Frustrated	BL	.13			-.07			-.12		
	AR		.03	-.08		.14	-.15		**.39****	.14
	MA		.10	.18		.14	-.09		**.39****	.12
Anxious	BL	.16			.08			-.12		
	AR		.15	.03		.33	.12		.22	-.04
	MA		**.30***	**.34***		.15	.13		.21	-.03
Irritated	BL	-.09			.03			-.12		
	AR		-.10	-.13		.15	-.12		**.50****	.18
	MA		.00	-.05		-.06	-.07		.25	.06

Note: BL=Baseline; AR=Anger Recall; MA=Mental Arithmetic; SBP Max=Peak systolic blood pressure score during the mental challenge task; SBP Δ=Difference between peak and baseline SBP; * = p<.05, **=p<0.01

Table 22: Emotional Reactivity Correlations with DBP Reactivity

		Healthy Controls (N= 47) Correlation			CAD (N= 31) Correlation			CAD + ICD (N= 44) Correlation		
		BL	DBP Max	DBP Δ	BL	DBP Max	DBP Δ	BL	DBP Max	DBP Δ
Depressed	BL	.02			.13			-.19		
	AR		**.34***	.28		.20	-.14		.24	.11
	MA		.19	.14		.04	.04		**.34***	-.01
Angry	BL	.08			-.28			-.12		
	AR		.18	.09		.21	.17		**.42***	**.47****
	MA		.12	-.04		-.31	-.16		**.34***	.18
Frustrated	BL	.15			.17			-.12		
	AR		.07	-.09		.07	.01		**.43****	.30
	MA		.02	.15		.07	.04		**.47****	.19
Anxious	BL	.01			.28			-.12		
	AR		.14	-.01		.21	-.02		.20	.18
	MA		.17	.22		-.19	-.04		.19	-.17
Irritated	BL	.03			.12			-.12		
	AR		-.02	-.13		.27	.14		**.37***	**.32***
	MA		-.06	-.05		-.12	.01		**.36***	.09

Note: BL=Baseline; AR=Anger Recall; MA=Mental Arithmetic; DBP Max=Peak diastolic blood pressure score during the mental challenge task; DBP Δ=Difference between peak and baseline DBP; * = p<.05, **=p<0.01

Table 23: Emotional Reactivity Correlations with HR Reactivity

		Healthy Controls (N= 47) Correlation			CAD (N= 31) Correlation			CAD + ICD (N= 44) Correlation		
		BL	HR Max	HR Δ	BL	HR Max	HR Δ	BL	HR Max	HR Δ
Depressed	BL	-.10			-.27			-.26		
	AR		.17	.17		-.13	-.08		-.06	.11
	MA		.12	.18		.003	-.02		.22	.04
Angry	BL	.04			.01			-.12		
	AR		.22	.03		-.17	-.26		.16	-.09
	MA		.18	.04		.04	.02		.19	.17
Frustrated	BL	.17			-.13			-.26		
	AR		.28	.02		-.04	.02		.29	.05
	MA		.15	.09		-.01	-.06		.21	-.05
Anxious	BL	.07			.08			-.26		
	AR		**.40****	.22		.17	.21		.22	.10
	MA		.28	.19		.33	.18		-.09	-.16
Irritated	BL	.12			-.12			-.26		
	AR		.13	-.13		-.3	-.28		**.31***	.05
	MA		.10	-.01		-.02	-.05		.05	-.22

Note: BL=Baseline; AR=Anger Recall; MA=Mental Arithmetic; HR Max=Peak heart rate score during the mental challenge task; HR Δ=Difference between peak and baseline HR; * = p<.05, **=p<0.01

Table 24: Prediction of SBP Reactivity to Anger Recall Adjusted for Frustration

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.07	4.28	.02	.07	4.28	**.02**
Frustrated	.07	2.85	.04	.00	.06	.81
Optimism	.07	2.12	.08	.00	.01	.95
Group x Optimism Interaction	.13	2.13	.02	.06	3.84	**.02**

Table 25: Prediction of SBP Reactivity to Anger Recall Adjusted for Depression

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.07	4.28	.02	.07	4.28	**.02**
Depression	.07	2.85	.04	.001	.07	.80
Optimism	.07	2.14	.08	.000	.05	.83
Group x Optimism Interaction	.13	2.81	.02	.06	3.87	**.02**

Table 26: Prediction of SBP Reactivity to Anger Recall Adjusted for Anger

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.07	4.28	.02	.07	4.28	**.02**
Angry	.07	2.88	.04	.001	.14	.71
Optimism	.07	2.15	.08	.000	.04	.90
Group x Optimism Interaction	.13	2.75	.02	.06	3.75	**.03**

Table 27: Prediction of SBP Reactivity to Mental Arithmetic Adjusted for Frustration

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.10	6.36	.002	.10	6.31	**.002**
Frustrated	.10	4.51	.01	.01	.82	.37
Optimism	.11	3.50	.01	.004	.52	.47
Group x Optimism Interaction	.14	3.12	.01	.03	2.30	.11

Table 28: Prediction of SBP Reactivity to Mental Arithmetic Adjusted for Depression

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.01	6.36	.002	.10	6.31	**.002**
Depression	.10	4.32	.01	.002	.30	.09
Optimism	.11	3.40	.01	.01	.81	.37
Group x Optimism Interaction	.14	3.17	.01	.04	2.50	.09

Table 29: Prediction of SBP Reactivity to Mental Arithmetic Adjusted for Anger

Predictors	R^2	F	p	R^2 Change	F Change	F change p value
Group status	.10	6.36	.002	.10	6.31	**.002**
Optimism	.11	3.75	.01	.003	.46	.50
Group x Optimism Interaction	.15	3.33	.01	.03	2.31	.10
Angry	.11	4.87	.003	.01	1.78	.18